

## Claims

- [c1] 1.A rotating electrical machine comprised of a primary device having a pair of relatively rotatable assemblies consisting of one assembly comprised of a plurality of circumferentially spaced permanent magnets of alternating polarity, the other of said assemblies being comprised of a plurality of radially extending, magnetic poles having ends cooperating with said permanent magnets and surrounded by coil windings and defining slots therebetween, relative rotation of said assemblies generating a cogging torque determined by the least common multiple of the number of said magnets and the number of said slots, and a cogging torque canceling device for generating a canceling cogging torque out of phase with and substantially canceling that of said primary assembly, said cogging torque canceling device having a second pair of relatively rotatable assemblies.
- [c2] 2.A rotating electrical machine as set forth in claim 1, wherein the cogging torque canceling device is selectively operable for selectively generating its cogging torque.
- [c3] 3.A rotating electrical machine as set forth in claim 2, wherein the cogging torque canceling device is operable only at lower speeds of relative rotation of the primary device.
- [c4] 4.A rotating electrical machine as set forth in claim 1, wherein the cogging torque canceling device generated the canceling cogging torque electrically.
- [c5] 5.A rotating electrical machine as set forth in claim 4, wherein the second pair of relatively rotatable assemblies of the cogging torque canceling device is comprised of one assembly comprised of a plurality of circumferentially spaced permanent magnets of alternating polarity, the other of said assemblies of said cogging torque canceling device being comprised of a plurality of radially extending, magnetic pole teeth having ends cooperating with said permanent magnets and surrounded by coil windings and defining slots therebetween, relative rotation of said second pair of relatively rotatable assemblies generating a canceling cogging torque determined by the least common multiple of the number of said magnets and the number of said slots.

- [c6] 6.A rotating electrical machine as set forth in claim 5, wherein the first and second pair of relatively rotatable assemblies have substantially the same construction and are out of phase with each other.
- [c7] 7.A rotating electrical machine as set forth in claim 6, wherein the phase difference between the first and second pair of relatively rotatable assemblies is equal to one half of the mechanical rotational angle of a single phase of the cogging torque of the first relatively rotatable assembly.
- [c8] 8.A rotating electrical machine as set forth in claim 5, wherein the number of magnetic pole teeth of the second pair of relatively rotatable assemblies is equal to the coggings of the first pair of relatively rotatable assemblies during a single rotation thereof.
- [c9] 9.A rotating electrical machine as set forth in claim 8, wherein the magnetic pole teeth of the second pair of relatively rotatable assemblies are equally spaced.
- [c10] 10.A rotating electrical machine as set forth in claim 9, wherein the cogging torque canceling device is selectively operable for selectively generating its cogging torque.
- [c11] 11.A rotating electrical machine as set forth in claim 10, wherein the selective operation of the cogging torque canceling device is achieved by controlling current in the coil windings of the second pair of relatively rotatable assemblies.
- [c12] 12.A rotating electrical machine as set forth in claim 8, wherein the magnetic pole teeth of the second pair of relatively rotatable assemblies are formed by two sets of rings each having the same number of magnetic pole teeth as the first pair of relatively rotatable assemblies with the pole teeth thereof equally spaced and slightly offset from each other in a circumferential direction.
- [c13] 13.A rotating electrical machine as set forth in claim 12, wherein the cogging torque canceling device is selectively operable for selectively generating its cogging torque.
- [c14] 14.A rotating electrical machine as set forth in claim 13, wherein the selective

operation of the cogging torque canceling device is achieved by controlling current in the coil windings of the second pair of relatively rotatable assemblies.

- [c15] 15.A rotating electrical machine as set forth in claim 1, wherein the cogging torque canceling device generates the canceling cogging torque mechanically.
- [c16] 16.A rotating electrical machine as set forth in claim 15, wherein the second pair of relatively rotatable assemblies comprises a cam mechanism for generating a sinusoidal force resisting relative rotation that is equal to the cogging torque of the first pair of relatively rotatable assemblies.
- [c17] 17.A rotating electrical machine as set forth in claim 16, wherein the cam mechanism comprises a rotating cam acting on a plurality of ball followers.
- [c18] 18.A rotating electrical machine as set forth in claim 17, wherein the cogging torque canceling device is selectively operable for selectively generating its cogging torque.
- [c19] 19.A rotating electrical machine as set forth in claim 18, wherein the selective operation of the cogging torque canceling device is achieved by moving the rotating cam acting and ball followers out of contact with each other.